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Kinematic and dynamic analysis of the manipulator for removal of rough tyres

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Abstract

The paper presents a kinematic and dynamic analysis of the manipulator for removal of rough vehicle tyres. Kinematic and dynamic analysis of the manipulator was performed by means of the Cosmos Motion 2.85 programme. Graphic dependence of kinematic and dynamic magnitudes of some solid bodies is closely connected with the dependence on the velocity of shift of the drive member as well as with dependence on the time. The model of the manipulator was created in Pro-engineer software.

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Keywords: kinematic analysis; dynamic analysis; numerical analysis; Cosmos Motion

1. Introduction

In relation to the kinematic and dynamic analysis and subsequent simulation [1–3] of the planar as well as spatial mechanisms, it is great solution to use Cosmos Motion software program. The considerable advantage of this mentioned program is based on its simplicity from the aspect of modelling and moreover, it is important to point out that utilisation of the mentioned program leads to results which are precise and accurate in the case of the numerical solution of the equations in the whole magnitude referring to motion of mechanism while the given results are obtained in the graphic form.

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2. Kinematic and dynamic analysis of the manipulator for removal of rough tyres

The manipulator for removal of rough tyres (Fig. 1) is composed of twenty five individual bodies which are held together by help of kinematic connections and it is in the accordance with real state. The computational model of the manipulator can be seen in the Fig. 2.

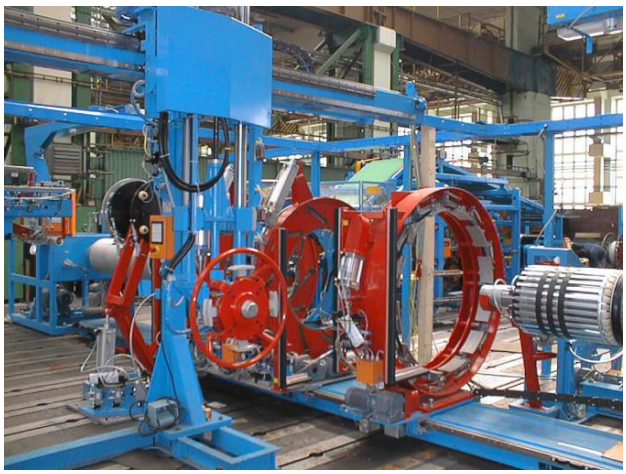

Fig. 1. The manipulator for removal of rough tyres.

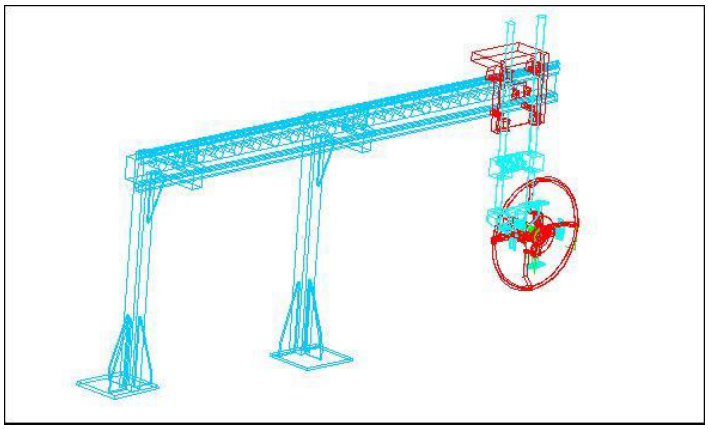

Fig. 2. Computational model of the manipulator.

Using the kinematic analysis [4–6], the main objective is connected with the determination and entering of the position domains, speed (velocity) domains as well as acceleration of the individual items in relation to the specified input values and it can be seen in the Table 1.

Table 1. Influences of external forces and kinematic phenomena on manipulator.

1.	maximum gravity or load capacity, using 22.5 ´´tyre	80 kg
2.	speed (velocity) of movement for manipulating member in horizontal direction	400 $mm.s^{-1}$
3.	speed (velocity) of movement for manipulating member in vertical direction	90 $mm.s^{-1}$
4.	speed (velocity) of disengaging for clamps used for removing	20 $mm.s^{-1}$

The simulation of operation relating to manipulator can be seen in the Fig. 3. In the given figure, there are 6 steps relating to technology of removing and manipulation with the tyre:

1. clamping of the tyre
2. removing of the tyre from the transferring of assembling or building up line
3. inspection of the tyre by operator
4. removing of the tyre above the rotating storage bin
5. tilting of the tyre
6. placing of the tyre into the rotating storage bin

It has to be pointed out that each one of the mentioned positions or steps is closely connected with specific influence referring to loading process of backbone frame of the manipulator.

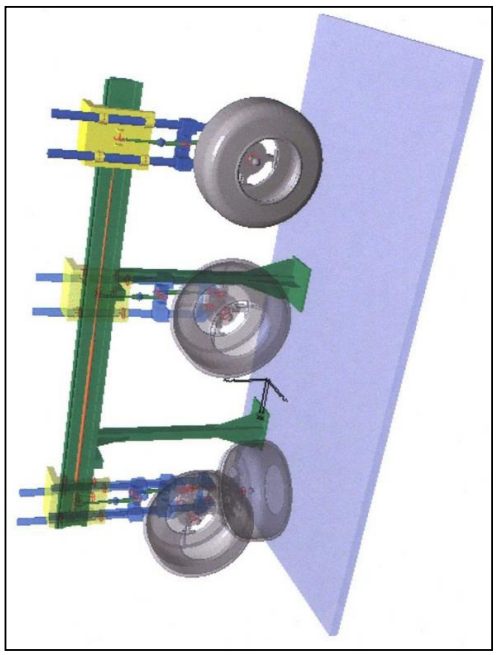

Fig. 3. Simulation of manipulator operation.

In the Fig. 4, there is the tyre, which is clamped in the clamps of manipulator as well as there is also the physical model for clamping mechanism. The course of the speed (velocity) as well as the acceleration of the movement of shifting link or frame can be seen in the Fig. 5 and 6.

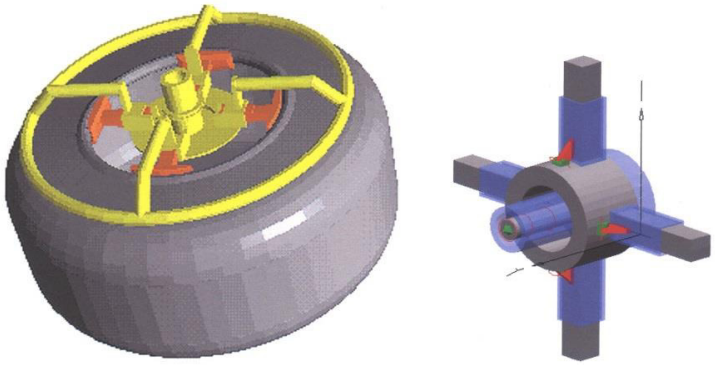

Fig. 4. Manipulator clamps and clamping mechanism for tyre clamping.

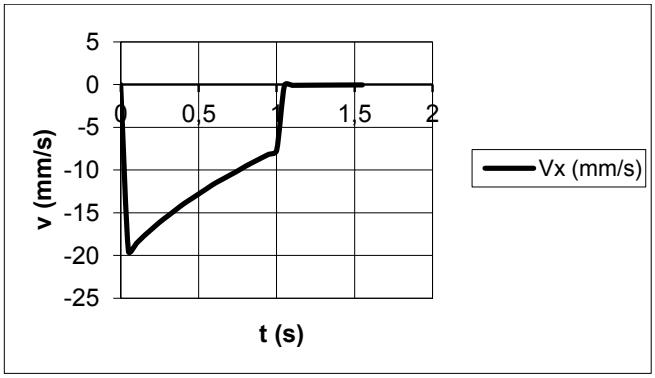

Fig. 5. Speed of the movement of shifting link (frame).

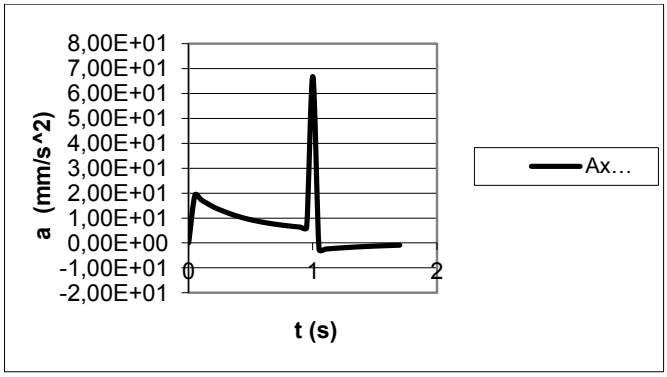

Fig. 6. Acceleration of the movement of shifting link (frame).

The main objective of the dynamic analysis is connected with specification of the loading for the individual items and determination of the courses relating to mutual reactions for individual kinematic connections [7]. The analysis was based on utilisation of the linear model. Relating to the analysis, the other important and utilised values were:

- modulus of elasticity (Young's modulus): $E = 2.1\ e^{11}$ (Pa),
- Poisson's ratio: $\mu = 0.3$,
- density of material: $\rho = 7850$ (kg.m^{-3}).

The course of interactions between the backbone frame and manipulating member in horizontal direction can be seen in Fig. 7.

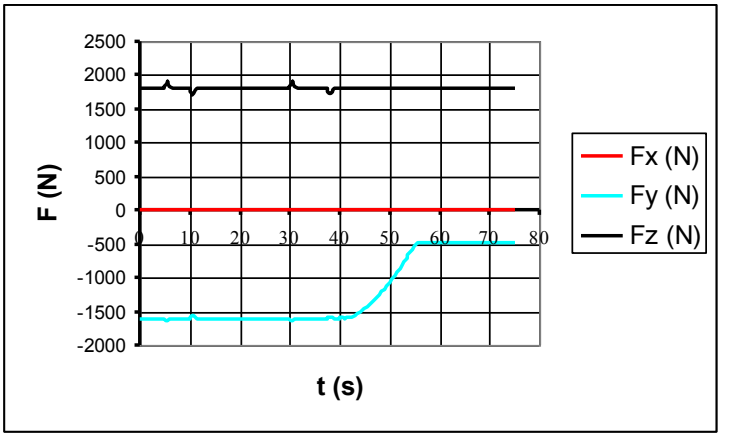

Fig. 7. Course of interactions – the backbone frame vs. horizontal manipulating member.

3. Summary

Based on the evaluation of the results, the utilisation of the Motion Program is significantly useful because it is effective way to determine all kinematic parameters of any mechanism and moreover, the loading for any point of the body system can be also specified. The tolerance for the position deviation was tested while the predetermined deviation was 10^{-9}. It is important to point out that from the aspect of convergence, it was not necessary to use more than five steps for each one position. On the other side, the convergence failure was connected with specification and entering of inaccurate parameters.

Acknowledgement

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